MELTBLOWN WEB

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to webs of meltblown fibers and to composite nonwoven fabrics that include a web of meltblown fibers. More specifically, the invention relates to meltblown webs that include multiple component fibers wherein a component of the fibers is comprised of a blend of polymers.

Description of Related Art

Thermoplastic resins have been extruded to form fibers for many years. These resins include polyolefins, polyesters, polyamides, and polyurethanes. The extruded fibers have been made into a variety of nonwoven fabrics including composite laminates such as spunbond-meltblown-spunbond ("SMS") composite sheets. In SMS composites, the exterior layers are spunbond fiber layers that contribute strength to the overall composite, while the core layer is a meltblown fiber layer that provides barrier properties.

U.S. Patent No. 5,616,408 discloses an SMS composite fabric in which the meltblown fibers are comprised of a blend of polyethylene and a polyethylene processing stabilizing component. The stabilizing component is added to the polyethylene so as to stiffen the soft, highly elongatable polyethylene resin so that the resin can be meltblown without substantial formation of shot, polymer globules and the like. The stabilizing component is disclosed as being another polymer such as a polyolefin, polyester or polyamide added to the polyethylene in an amount of about 1 to 15 percent by weight based upon the weight to the polyethylene polymer.

U.S. Patent No. 4,547,420 discloses bicomponent meltblown fibers and webs made from such fibers. One of the components is crystallizable poly(ethylene terephthalate) and the other component is polypropylene.

SUMMARY OF THE INVENTION

A first embodiment of the present invention is directed to a multiple component meltblown web comprised of at least 95% by weight of multiple component meltblown fibers having an average effective diameter of less than 10 microns, the multiple component meltblown fibers comprised of a first polymer component and a second polymer component distinct from the first polymer

component, the first polymer component being comprised of from 1% to 99% by weight of a first polymer and from 99% to 1% by weight of a second polymer wherein the first and second polymers are selected from the group consisting of polyolefins, polyesters, polyamides, polystyrene, polyurethanes, fluoropolymers, olefinic ionomer resins, random co-polymers of ethylene and methacrylic acid, and random co-polymers of ethylene and vinyl acetate.

In another embodiment, the present invention is directed to a multiple component meltblown web comprised of at least 95% by weight of meltblown fibers having an average effective diameter of less than 10 microns, the meltblown fibers comprised of a first polymer component and a second polymer component distinct from the first polymer component, the first polymer component being comprised of from 1% to 99% by weight of a first polymer and from 99% to 1% by weight of a second polymer wherein the first and second polymers consist essentially of non-elastomeric polymers.

In another embodiment, the present invention is directed to a multiple component meltblown web comprised of at least 95% by weight of meltblown fibers having an average effective diameter of less than 10 microns, the meltblown fibers comprised of a first polymer component and a second polymer component distinct from the first polymer component, the first polymer component being comprised of from 1% to 99% by weight of a first polymer and from 99% to 1% by weight of a second polymer wherein the first and second polymers consist essentially of elastomeric polymers.

In another embodiment, the present invention is directed to a composite sheet comprising a first fibrous layer having a first side and an opposite second side, a second fibrous layer bonded to the first side of the first fibrous layer, the first fibrous layer being a multiple component meltblown web comprised of at least 95% by weight of multiple component meltblown fibers having an average effective diameter of less than 10 microns, the multiple component meltblown fibers comprised of a first polymer component and a second polymer component distinct from the first polymer component, the first polymer component being comprised of from 1% to 99% by weight of a first polymer and from 99% to 1% by weight of a second polymer, the second fibrous layer comprised of at least 95% by weight of second layer fibers having an average effective diameter that is greater than the average effective diameter of the meltblown fibers of the first fibrous layer.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate the presently preferred embodiments of the invention.

Figure 1 is a schematic perspective view of a meltblown web according to the invention.

Figure 2 is a diagrammatical cross-sectional view of a composite nonwoven fabric incorporating the meltblown web of Figure 1.

Figure 3 is a diagrammatical cross-sectional view of another composite nonwoven fabric incorporating the meltblown web of Figure 1.

Figure 4 is a schematic diagram of a portion of an apparatus used for producing the meltblown webs of the invention.

Figure 5 is a schematic illustration of an apparatus for producing a spunbond nonwoven layer for use in the composite nonwoven fabric of the invention.

Figure 6 is schematic illustration of an apparatus for producing the composite nonwoven fabric of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The term "polymer" as used herein, generally includes but is not limited to, homopolymers, copolymers (such as for example, block, graft, random and alternating copolymers), terpolymers, etc. and blends and modifications thereof. Furthermore, unless otherwise specifically limited, the term "polymer" shall include all possible geometrical configurations of the material. These configurations include, but are not limited to isotactic, syndiotactic and random symmetries.

The term "polyolefin" as used herein, is intended to mean any of a series of largely saturated open chain polymeric hydrocarbons composed only of carbon and hydrogen. Typical polyolefins include, but are not limited to, polyethylene, polypropylene, polymethylpentene and various combinations of the ethylene, propylene, and methylpentene monomers.

The term "polyethylene" as used herein is intended to encompass not only homopolymers of ethylene, but also copolymers wherein at least 85% of the recurring units are ethylene units.

The term "polypropylene" as used herein is intended to embrace not only homopolymers of propylene but also copolymers where at least 85% of the recurring units are propylene units.

The term “polyester” as used herein is intended to embrace polymers wherein at least 85% of the recurring units are condensation products of carboxylic acids and dihydroxy alcohols with polymer linkages created by formation of an ester unit. This includes, but is not limited to, aromatic, aliphatic, saturated, and unsaturated acids and di-alcohols. The term "polyester" as used herein also includes copolymers (such as block, graft, random and alternating copolymers), blends, and modifications thereof. A common example of a polyester is poly(ethylene terephthalate) which is a condensation product of ethylene glycol and terephthalic acid.

The term "polystyrene" as used herein is intended to embrace not only homopolymers of styrene but also copolymers where at least 85% of the recurring units are styrene units.

The term “meltblown fibers” as used herein, means fibers formed by extruding a molten thermoplastic polymer through a plurality of fine, usually circular, capillaries as molten threads or filaments into a high velocity gas (e.g. air) stream. The high velocity gas stream attenuates the filaments of molten thermoplastic polymer material to reduce their diameter to between 0.5 and 10 microns. Meltblown fibers are generally discontinuous fibers but may also be continuous. Meltblown fibers carried by the high velocity gas stream are normally deposited on a collecting surface to form a web of randomly dispersed fibers.

The term “meltspun fibers” as used herein means small diameter fibers which are formed by extruding molten thermoplastic polymer material as filaments from a plurality of fine, usually circular, capillaries of a spinnerette with the diameter of the extruded filaments then being rapidly reduced. Meltspun fibers are generally continuous and have an average diameter of greater than about 5 microns.

The term “nonwoven fabric, sheet or web” as used herein means a structure of individual fibers or threads that are positioned in a random manner to form a planar material without an identifiable pattern, as in a knitted fabric.

The terms “multiple component fiber” and “multiple component filament” as used herein refer to any fiber or filament that is composed of at least two distinct polymers which have been spun together to form a single fiber or filament. The term “fiber” as used herein refers to both discontinuous and continuous fibers. The at least two distinct polymer (or fiber) components useable herein may be chemically different or they may be chemically the same polymer, but having different physical characteristics, such as intrinsic viscosity, melt viscosity, die swell, density, crystallinity, and melting point or softening point.

For example, the two fiber components may be linear low density polyethylene and high density polyethylene or a high viscosity polypropylene and a low viscosity polypropylene. The at least two distinct polymer (or fiber) components are preferably arranged in distinct substantially constantly positioned zones across the cross-section of the multiple component fibers and may extend substantially continuously along the length of the fibers. Preferably the multiple component fibers are bicomponent fibers which are made from two distinct polymer (or fiber) components. Multiple component fibers are distinguished from fibers which are extruded from a homogeneous melt blend of polymeric materials. Multiple component fibers useful in practicing the current invention include sheath-core and side-by-side fibers. Preferably the multiple component meltblown fibers which form the webs of the current invention are bicomponent fibers in which the two distinct polymers are arranged in a side-by-side configuration.

The term "multiple component web" as used herein refers to a nonwoven web comprising multiple component fibers or filaments. The term "bicomponent web" as used herein refers to a multiple component web comprising bicomponent fibers. Multiple component webs may include both single component and multiple component fibers or filaments. The term "multiple component meltblown web" as used herein means a web comprising multiple component meltblown fibers spun from fine capillaries as molten filaments containing multiple and distinct polymer components, which molten filaments are attenuated by a high velocity gas stream and deposited on a collecting surface as a web of randomly dispersed fibers.

Reference will now be made in detail to the presently preferred embodiments of the invention, examples of which are illustrated below.

A preferred embodiment of the meltblown web of the invention is shown in Figure 1. The fine fiber layer 14 comprises a multiple component meltblown web formed from at least two polymer components simultaneously spun from a series of spinning orifices. According to the invention, at least one of the polymer components comprises a blend of two or more polymers. The fibers in the multiple component meltblown web 14 generally have an average effective diameter of between about 0.5 microns and 10 microns, and more preferably between about 1 and 6 microns, and most preferably between about 2 and 4 microns. As used herein, the "effective diameter" of a fiber with an irregular cross section is equal to the diameter of a hypothetical round fiber having the same cross sectional area. The fibers of the meltblown web 14 are sufficiently long to be entangle with other fibers in the web. Upon being laid down, the entangled fibers of the web 14 form cohesive web structure.

The configuration of the fibers in the bicomponent web 14 is preferably a side-by-side arrangement in which most of the fibers are made of two side-by-side polymer components that extend for substantially the whole length of each fiber. Alternatively, these bicomponent fibers may have a sheath/core arrangement wherein one polymer is surrounded by another polymer, an "islands-in-the-sea" arrangement in which multiple strands of one polymer are imbedded in another polymer, or any other multiple component fiber structure.

According to the invention, the fine fibers of the layer 14 are produced according to a multiple component meltblowing process, for example a process in which two or more extruders supply melted polymer components to a die tip where the polymer components are passed through fine capillary openings and pneumatically drawn by a jet of attenuating gas (e.g. air) around the fine capillary openings in the die. The fibers are deposited on a collecting surface such as a moving belt or screen, a scrim, or another fibrous layer. Fibers produced by melt blowing may be discontinuous or continuous fibers having an effective diameter in the range of about 0.5 to about 10 microns.

The fibers of the multiple component meltblown web of the layer 14 can be meltblown using a meltblowing apparatus having capillary die openings like that shown in Figure 4. In the sectional view of a meltblowing spin block 20 shown in Figure 4, two different polymeric components are melted in parallel extruders (not shown) and metered separately by gear pumps (not shown) to conduits 25 and 26 that are divided by a plate 27. At least one of the polymer components comprises a mixture or blend of different polymers. The polymer blend can be formed by feeding the different polymers, in pelletized form, to a screw extruder. The extruder melts and mixes the polymer blend before feeding the polymer blend to the spin block 20. In the spin block 20 the polymer blend component comes into contact with the other polymer component or components as it moves toward a line of capillary orifices 21. The second polymer component may be a single polymer or a blend of polymers.

Alternatively, the fibers of the multiple component meltblown web of the layer 14 can be meltblown using a meltblowing apparatus like that described in U.S. Patent No. 4,795,668, which is hereby incorporated by reference. In such an apparatus, the different polymeric components are melted in parallel extruders and metered separately through gear pumps into a die cavity. From the die cavity, the polymer components are extruded together through a line of capillary orifices. According to another alternative, the polymer components can be fed, in an already layered form, into the cavity of the spin block from which the capillary orifices are supplied with the multiple component polymer

stream. A post-coalescent die, as disclosed in copending provisional application no. 60/223,040, filed August 4, 2000, in which the distinct polymer components are extruded through separate extrusion orifices and are contacted and fused after exiting the capillaries to form multiple component meltblown fibers, may also be used.

After exiting the capillary orifices, a jet of gas, e.g. hot air, supplied from the channels 28 attenuates the emerging polymer filaments to form meltblown fibers. Without wishing to be bound by theory, it is believed that the air jet may fracture some of the meltblown fibers into even finer fibers. The resulting meltblown fibers are believed to include bicomponent fibers in which each fiber is made of two separate polymer components that both extend the length of the meltblown fiber in a side-by-side configuration. It is also believed that some of the fractured fibers may contain just one polymer component. The fine fibers of layer 14 could alternatively be produced by other known meltblowing processes, as for example by the process wherein an individual air nozzle surrounds each capillary, as disclosed in U.S. Patent No. 4,380,570.

By making one or more of the components of the multiple component meltblown fibers from a blend of polymers, applicants have found that the spinning performance and meltblown web quality may be improved. Applicants have further found that it is possible to very specifically tailor the properties of the meltblown webs made from such bicomponent fibers. For example, by using a polymer blend in one component of a meltblown bicomponent web, it is possible to form a web of fibers that have dissimilar polymer components but are also resistant to splitting. For example, bicomponent meltblown fibers can be meltblown where one component is a polyester such as poly(ethylene terephthalate) and the other component is primarily a polyolefin such as polyethylene. By blending a minor amount of a polyester polymer, such as poly(butylene terephthalate) into the polyethylene, the polyethylene component should adhere more readily to the poly(ethylene terephthalate) component. Alternatively, a polymer, such as a fluoropolymer, can be blended into one of the components in order to enhance splitting of the fibers. According to one preferred embodiment of the invention, the polymer blend component may further include a compatibilizer for the polymers in the blend.

Polymers suitable for use in preparing the multiple component meltblown webs of the current invention include polyolefins, polyesters, polyamides, polystyrene, polyurethanes including those made by combining hard segments comprising 4,4-diphenyl-methane diisocyanate with soft segments comprising either a polyester or poly-ether based polyol such as Pellethane®

polyurethanes available from Dow Plastics, fluoropolymers, random co-polymers of ethylene and methacrylic acid such as Nucrel® resins marketed by DuPont, olefinic ionomer resins such as random co-polymers of ethylene and methacrylic acid which have been neutralized with metal ions such as sodium or magnesium for example Surlyn® ionomer resins marketed by DuPont, and random co-polymers of ethylene and vinyl acetate. Preferred polymers include polyethylene, polypropylene, poly(ethylene terephthalate), poly(trimethylene terephthalate), poly(butylene terephthalate), poly(hexamethylene adipamide), and poly(ε-caprolactam).

Preferred combinations of polymer components include polyester/blend of a polyester and a polyolefin, polyolefin/blend of two distinct polyolefins, and polyester/blend of a polyolefin with an olefinic ionomer resin. In a preferred embodiment wherein the multiple component meltblown fibers are bicomponent fibers, preferred combinations of polymer components include poly(ethylene terephthalate)/blend of polyethylene with poly(butylene terephthalate), polypropylene/blend of a polyethylene with a polypropylene, and poly(ethylene terephthalate)/blend of polyethylene with an ionomeric random co-polymer of ethylene and methacrylic acid. The polymer components of the multiple component meltblown fibers may consist essentially of 100% elastomeric polymers or they may consist essentially of 100% non-elastomeric polymers. By "elastomeric polymer" is meant a polymer which in monocomponent meltspun fiber form, free of diluents, has a break elongation in excess of 100% and which when stretched to twice its length, held for one minute, and then released, retracts to less than 1.5 times its original length within one minute of being released. As used herein, "non-elastomeric polymer" means any polymer which is not an elastomeric polymer.

The composite sheet 10 shown in Figure 2 is a three layer composite fabric in which the inner layer is comprised of the multiple component meltblown web 14 described above. The fine fibers meltblown web 14 is sandwiched between outer layers 12 and 16, which are each comprised of larger and stronger and bonded fibers. The very fine fibers of inner layer 14, when formed into the layer 14, can provide a barrier layer with extremely fine passages. The bonded fiber layers 12 and 16 are comprised of coarser and stronger fibers that contribute strength, and in some instances barrier, to the composite sheet. The composite sheet of the invention may alternatively be formed as a two layer composite 18, as shown in Figure 3. In the two layer composite sheet, the fine fiber layer 14 is attached on just one side to the coarser and stronger bonded layer 12. According to other alternative embodiments of the invention, the composite

sheet may be made with multiple layers of fine fibers like the layer 14, or it may be made with more than two layers of coarser and stronger fiber layers like the layers 12 and 16.

According to the invention, the larger and stronger bonded fibers of the layers 12 and 16 are conventional meltspun fibers or some other type of strong spunbond fiber. Preferably, the meltspun fibers are substantially continuous fibers. Alternatively, the layers 12 and 16 could be an air-laid or wet-laid staple fiber web or a carded web wherein the fibers are bonded to each other to form a strong web structure. The fibers of layers 12 and 16 should be made of a polymer to which the fine fibers of the core layer 14 can readily bond.

Layers 12 and 16 are preferably made from bicomponent meltspun fibers. The components of the meltspun fibers of the layers 12 and 16 may consist of a single polymer or a blend of polymers. According to one preferred embodiment of the invention, the meltspun fibers of layers 12 and 16 comprise polyester/polyethylene bicomponent fibers. The polyester component contributes to the strength to the fabric while the polyethylene component makes the fabric softer and more drapable. In addition, the polyethylene component has a lower melting temperature than the polyester component of the fiber so as to make the fiber layers 12 and 16 more readily bondable to the fine fibers of the core layer 14 using a thermal bonding process. Alternatively, layers 12 and 16 could be comprised of a blend of single polymer component fibers, as for example, a spunbond web wherein a portion of the fibers are polyethylene fibers and a portion of the fibers are polyester fibers.

According to the preferred embodiment of the invention, the larger and stronger fibers of the layers 12 and 16 are substantially continuous spunbonded fibers produced using a high speed melt spinning process, such as the high speed spinning processes disclosed in U.S. Patent Nos. 3,802,817; 5,545,371; and 5,885,909; which are hereby incorporated by reference. According to the preferred high speed melt spinning process, one or more extruders supply melted polymer to a spin block where the polymer is extruded through a plurality of openings to form a curtain of filaments. The filaments are partially cooled in an air quenching zone. The filaments are then pneumatically drawn to reduce their size and impart increased strength. The filaments are deposited on a moving belt, scrim or other fibrous layer. Fibers produced by the preferred high speed melt spinning process are substantially continuous and have a diameter of from 5 to 30 microns. These fibers can be produced as single component fibers, as multiple component fibers, or as some combination thereof. Multiple component meltspun

fibers can be made in various known cross-sectional configurations, including side-by-side, sheath-core, segmented pie, or islands-in-the-sea configurations.

An apparatus for producing nonwoven webs of high strength bicomponent meltspun fibers at high speeds is schematically illustrated in Figure 5. In this apparatus, two thermoplastic polymers are fed into the hoppers 40 and 42, respectively. The polymer in hopper 40 is fed into the extruder 44 and the polymer in the hopper 42 is fed into the extruder 46. The extruders 44 and 46 each melt and pressurize the polymer and push it through filters 48 and 50 and metering pumps 52 and 54, respectively. The polymer from hopper 40 is combined with polymer from hopper 42 in the spin block 56 by known methods to produce the desired multiple component filament cross sections mentioned above, as for example by using a multi-component spin block like that disclosed in U.S. Patent No. 5,162,074, which is hereby incorporated by reference. Where the filaments have a sheath-core cross section, a lower melting polymer is typically used for the sheath layer so as to enhance thermal bonding. If desired, single component fibers can be spun from the multiple component apparatus shown in Figure 5 by simply putting the same polymer in both of the hoppers 40 and 42.

The melted polymers exit the spin block 56 through a plurality of capillary openings on the face of the spinneret 58. The capillary openings may be arranged on the spinneret face in a conventional pattern (rectangular, staggered, etc.) with the spacing of the openings set to optimize productivity and fiber quenching. The density of the openings is typically in the range of 500 to 8000 holes/meter width of the pack. Typical polymer throughputs per opening are in the range of 0.3 to 5.0 g/min.

The filaments 60 extruded from the spin block 56 are initially cooled with quenching air 62 and then drawn by a pneumatic draw jet 64 before being laid down. The quenching air is provided by one or more conventional quench boxes that direct air against the filaments at a rate of about 0.3 to 2.5 m/sec and at a temperature in the range of 5° to 25° C. Typically, two quench boxes facing each other from opposite sides of the line of filaments are used in what is known as a co-current air configuration. The distance between the capillary openings and the draw jet may be anywhere from 30 to 130 cm, depending on the fiber properties desired. The quenched filaments enter the pneumatic draw jet 64 where the filaments are drawn by air 66 to fiber speeds in the range of from 2000 to 12,000 m/min. This pulling of the filaments draws and elongates the filaments near the spinneret face as the filaments pass through the quench zone. The filaments 67 exiting the draw jet 64 are thinner and stronger than the filaments that were extruded from the spin block. The substantially

continuous filaments 67 are strong fibers having a tensile strength of at least 1 gpd, and preferably having an effective diameter of from 5 to 30 microns. The filaments 67 are deposited onto a laydown belt or forming screen 68 as substantially continuous filaments. The distance between the exit of the draw jet 64 and the laydown belt is varied depending on the properties desired in the nonwoven web, and generally ranges between 13 and 76 cm. A vacuum suction is usually applied through the laydown belt to help pin the fiber web. Where desired, the resulting web 12 can be passed between thermal bonding rolls 72 and 74 before being collected on the roll 78.

The composite nonwoven fabric of the invention can be produced in-line using the apparatus that is shown schematically in Figure 6. Alternatively, the layers of the composite sheet can be produced independently and later combined and bonded to form the composite sheet. The apparatus shown in Figure 6 includes spunbonded web production sections 80 and 94 that are preferably like the high speed melt spinning apparatus described with regard to Figure 5. The apparatus of Figure 6 further includes a meltblown web production section 82 incorporating the meltblowing apparatus of the type described with regard to Figure 4. For purposes of illustration, the two spunbond web production sections 80 and 94 are shown making bicomponent fibers. It is contemplated that the spunbond web production sections 80 and 94 could be replaced by units designed to produce spunbond webs having just one polymer component or having three or more polymer components. It is also contemplated that more than one spunbond web production section could be used in series to produce a web made of a blend of different single or multiple component fibers. It is further contemplated that the polymer(s) used in section 94 could be different than the polymer(s) used in section 80. Where it is desired to produced a composite sheet having just one spunbond layer and one fine fiber layer (as shown in Figure 3), the second spunbond web production section 94 can be turned off or eliminated.

According to the preferred embodiment of the invention, in the spunbond web production sections 80 and 94 of the apparatus shown in Figure 6, two thermoplastic polymer components A and B are melted, filtered and metered (not shown) to the spin blocks 56 and 96 as described above with regard to Figure 4. The melted polymer filaments 60 and 100 are extruded from the spin blocks through spinneret sets 58 and 98, respectively, as described above with regard to Figure 5. The filaments may be extruded as bicomponent filaments having a desired cross section, such as a sheath-core filament cross section. Preferably, a lower melting temperature polymer is used for the sheath section while a higher melting temperature polymer is used for the core section. The

resulting filaments 60 and 100 are cooled with quenching air 62 and 102 as described above. The filaments next enter pneumatic draw jets 64 and 104 and are drawn by drawing air 66 and 106 as described above with regard to Figure 5. The fibers 67 from the spunbond web production section 80 are deposited onto forming screen 68 so as to form a spunbond layer 12 on the belt.

According to the preferred embodiment of the invention, two thermoplastic polymer components C and D are combined to make a meltblown bicomponent web in the meltblown web production section 82. At least one of these components comprises a blend of two or more different polymers. The polymer blend component is preferably formed by mixing pellets of the two polymers and extruding them together. The second polymer component may be a single polymer or another polymer blend formed in the same manner. The polymer components C and D are melted, filtered, and then metered (not shown) into the meltblowing spin block 84. The melted polymers are combined in the spin block 84 and exit the spin block through a line of capillary openings in die like those described above with regard to Figure 4. Preferably, the spin block 84 generates the desired side-by-side fiber cross section. Alternative spin block arrangements can be used to produce alternative fiber cross sections, such as a sheath-core cross section. A jet of gas 88, such as hot air, supplied from the channels 90 impacts on opposite sides of the exiting filaments 91 and attenuates each filament 91 immediately after each filament exits its capillary opening to form meltblown fibers. The meltblown fibers 91 are deposited onto spunbond layer 12 to create the cohesive multiple component meltblown web layer 14.

Where a second spunbond web production section 94 is used, substantially continuous spunbond fibers 107 from the spunbond web production section 80 may be deposited onto the meltblown layer 14 so as to form a second spunbond layer 16 on web. The layers 12 and 16 do not necessarily have to have the same composition, thickness or basis weight.

The spunbond-meltblown-spunbond web structure is passed between thermal bonding rolls 72 and 74 in order to produce the composite nonwoven web 10 which is collected on a roll 78. Preferably, the bonding rolls 72 and 74 are heated rolls maintained at a temperature within plus or minus 20° C of the lowest melting temperature polymer in the composite. For a polyethylene-containing composite sheet, a bonding temperature in the range of 115-120 °C and a bonding pressure in the range of 350-700 N/cm can be applied to obtain good thermal bonding. Alternative methods for bonding the layers of the composite sheet include calender bonding, ultrasonic bonding, through-air bonding, steam bonding, and adhesive bonding.

TEST METHODS

In the description above and in the non-limiting examples that follow, the following test methods were employed to determine various reported characteristics and properties. ASTM refers to the American Society for Testing and Materials, and AATCC refers to the American Association of Textile Chemists and Colorists.

Basis Weight is a measure of the mass per unit area of a fabric or sheet and was determined by ASTM D-3776, which is hereby incorporated by reference, and is reported in g/m^2.

Hydrostatic Head is a measure of the resistance of the sheet to penetration by liquid water under a static pressure. The test was conducted according to AATCC-127, which is hereby incorporated by reference, and is reported in centimeters.

Frazier Air Permeability is a measure of air flow passing through a sheet under at a stated pressure differential between the surfaces of the sheet and was conducted according to ASTM D 737, which is hereby incorporated by reference, and is reported in $m^3/min/m^2$.

This invention will now be illustrated by the following non-limiting examples which are intended to illustrate the invention and not to limit the invention in any manner.

EXAMPLES

COMPARATIVE EXAMPLE A

This example demonstrates preparation of a SMS sheet by sandwiching and bonding a bicomponent meltblown layer between two bicomponent spunbond layers. The bicomponent meltblown layer is made of bicomponent meltblown fibers containing two polymer components wherein each polymer component is a single polymer.

A meltblown bicomponent web was made with a polyethylene component and a poly(ethylene terephthalate) component. The polyethylene component was made from linear low density polyethylene with a melt index of 150 g/10 minutes (measured according to ASTM D-1238) available from Dow as ASPUN 6831A. The polyester component was made from poly(ethylene terephthalate) with an intrinsic viscosity of 0.53 (as measured in U.S. Patent 4,743,504) available from DuPont as Crystar® polyester (Merge 4449). The polymer was crystalized and dried prior to extrusion. The polyethylene polymer was heated to 450° F (232 °C) and the polyester polymer was heated to 572° F (300° C) in separate extruders. The two polymers were separately extruded,

filtered and metered to a bicomponent spin block arranged to provide a side-by-side fiber cross section. The die of the spin block was heated to 599°F (315°C). The die had 601 capillary openings arranged in a 24 inch (61 cm) line. The polymers were spun through the each capillary at a polymer throughput rate of 0.80 g/hole/min. Attenuating air was heated to a temperature of 612°F (322° C) and supplied at a rate of 420 standard cubic feet per minute (scfm) (11.9 m^3/min) through two 0.8 mm wide air channels. The two air channels ran the length of the 24 inch line of capillary openings, with one channel on each side of the line of capillaries set back 1mm from the capillary openings. The polyethylene was supplied to the spin block at a rate of 23.1 kg/hr and the polyester was supplied to the spin block at a rate of 5.8 kg/hr. A bicomponent meltblown web was produced that was 80 weight percent polyethylene and 20 weight percent polyester. The meltblown fibers were collected on a moving forming screen to produce a meltblown web. Operating the meltblowing process under the conditions of this example resulted in the formation of a significant amount of "fly", i.e. broken filaments that were blown away from the laydown zone by the attenuating air stream. The meltblown web was collected on a roll. The meltblown web had a basis weight of 17.5 g/m^2.

The spunbond outer layers were made from bicomponent fibers with a sheath-core cross section. The spunbond fibers were made using an apparatus like that described above with regard to Figure 5. Spunbond webs with a basis weight of 15 g/m^2 were produced for use in the outer layers of the composite sheet. The spunbond bicomponent fibers were made from linear low density polyethylene with a melt index of 27 g/10 minutes (measured according to ASTM D-1238) available from Dow as ASPUN 6811A, and poly(ethylene terephthalate) polyester with an intrinsic viscosity of 0.53 (as measured in U.S. Patent 4,743,504) available from DuPont as Crystar® polyester (Merge 3949). The polyester resin was crystallized at a temperature of 180°C and dried at a temperature of 120°C to a moisture content of less than 50 ppm before use.

The polyester was heated to 290°C and the polyethylene was heated to 280° C in separate extruders. The polymers were extruded, filtered and metered to a bicomponent spin block maintained at 295°C and designed to provide a sheath-core filament cross section. The polymers were spun through the spinneret to produce bicomponent filaments with a polyethylene sheath and a poly(ethylene terephthalate) core. The total polymer throughput per spin block capillary was 0.4 g/min. The polymers were metered to provide fibers that were 30% polyethylene (sheath) and 70% polyester (core), based on fiber weight. The filaments were cooled in a 15 inch (38.1 cm) long quenching zone with quenching

air provided from two opposing quench boxes a temperature of 12° C and velocity of 1 m/sec. The filaments passed into a pneumatic draw jet spaced 20 inches (50.8 cm) below the capillary openings of the spin block where the filaments were drawn at a rate of approximately 9000 m/min. The resulting smaller, stronger substantially continuous filaments were deposited onto a laydown belt with vacuum suction. The fibers in the webs had an effective diameter in the range of 6 to 8 microns. The resulting webs were passed between two thermal bonding rolls to lightly tack the web together for transport using a point bonding pattern at a temperature of 100°C and a nip pressure of 100 N/cm. The line speed during bonding was 150 m/min. The lightly bonded spunbond webs were each collected on a roll.

The composite nonwoven sheet was prepared by unrolling the 15 g/m^2 basis weight spunbond web onto a moving belt. The meltblown bicomponent web was unrolled and laid on top of the moving spunbond web. A second roll of the 15 g/m^2 basis weight spunbond web was unrolled and laid on top of the spunbond-meltblown web to produce a spunbond-meltblown-spunbond composite nonwoven web. The composite web was thermally bonded between an engraved oil-heated metal calender roll and a smooth oil heated metal calender roll. Both rolls had a diameter of 466 mm. The engraved roll had a chrome coated non-hardened steel surface with a diamond pattern having a point size of 0.466mm^2, a point depth of 0.86 mm, a point spacing of 1.2 mm, and a bond area of 14.6%. The smooth roll had a hardened steel surface. The composite web was bonded at a temperature of 120 °C, a nip pressure of 350 N/cm, and a line speed of 50 m/min. The bonded composite sheet was collected on a roll. The final basis weight of this composite nonwoven sheet was 51.6 g/m^2.

EXAMPLE 1

This example demonstrates preparation of a SMS sheet according to the current invention. The SMS sheet was made by sandwiching and bonding a bicomponent meltblown layer between two bicomponent spunbond layers. The SMS sheet was substantially identical to the SMS sheet of Comparative Example A, except that the bicomponent meltblown layer was made from two polymer components wherein one polymer component is a blend of two polymers and the second polymer component is a single polymer.

A composite sheet was formed according to the procedure of Comparative Example A except the polyethylene component in the meltblown web was made up of a blend of 90% by weight Dow ASPUN 6831A and 10% by

weight Hoechst Celanese 1300A poly(butylene terephthalate). The poly(butylene terephthalate) acts as a spinning aid to the polyethylene. Also, the meltblowing process was altered as follows: the polyethylene/poly(butylene terephthalate) blend was heated to 260°C and the attenuating air flow rate was changed to 425 scfm (12.04 m^3/min). During operation of the meltblowing process, no formation of "fly" was observed. Process conditions for the meltblowing processes for Comparative Example A and Example 1 are summarized in Table 1. The physical properties of the meltblown webs and composite SMS sheets are reported in Table 2.

Comparing Example 1 with Comparative Example A shows that the hydrostatic head is higher for the web of Example 1 with the poly(butylene terephthalate) in the polyethylene component than the web of Comparative Example A, which was substantially identical to the web of Example 1, except for the absence of the poly(butylene terephthalate) in the polyethylene component of the web of Comparative Example A. It is believed that the improved hydrostatic head of Example 1 results from an improvement in the web uniformity when a blend of polymers is used as one of the polymer components in the multiple component meltblown fibers.

TABLE 1

MELTBLOWN PROCESS CONDITIONS

Example	T_{PE} (°C)	T_{PET} (°C)	T_{Die} (°C)	Air Flow (scfm)**	Throughput (g/hole/min)	Weight PE (kg/hr)	Weight PET (kg/hr)	Weight Ratio (%PE)
A	232	300	315	420	0.80	23.1	5.8	80
1*	260	300	315	425	0.80	23.1	5.8	80

Where T = Temperature, PE = Polyethylene, PET = Poly(ethylene terephthalate)

*In Example 1, the polyethylene component was made up of a blend of 90% by weight polyethylene and 10% by weight poly(butylene terephthalate).
**1scfm = 1.699 m^3/hr

TABLE 2

NONWOVEN WEB PROPERTIES

Example	Weight Ratio (%PE)	Basis weight of Meltblown Web (g/m^2)	Basis weight of Composite Sheet (g/m^2)	Hydrostatic Head of Composite Sheet (cm)	Frazier Air Permeability of Composite Sheet ($m^3/min/m^2$)
A	80	17.5	51.6	55.3	17.4
1*	80	15.9	49.9	72.0	9.8

*In Example 1, the polyethylene component was made up of a blend of 90% by weight polyethylene and 10% by weight poly(butylene terephthalate).

COMPARATIVE EXAMPLE B

This example demonstrates formation of a bicomponent meltblown web in which the first component is a high viscosity polypropylene and the second component is a low viscosity polypropylene.

A meltblown bicomponent web was made with a high viscosity polypropylene component (PP1) and a low viscosity polypropylene component (PP2). The high viscosity polypropylene component was made from a polyproylene resin with a melt flow rate of 35 (ASTM D1238-00) available from Exxon as 3155. The low visoscity polypropylene component was made from a polypropylene resin with a melt flow rate of 1200 (ASTM D1238-00) available from Exxon as 3546G. Both polymers were heated to 550° F (288°C) in separate extruders. The two polymers were separately extruded, filtered, and metered to a bicomponent spin block arranged to provide a side-by-side filament cross section. The die of the spin block was heated to 550°F (288°C). The die had 601 capillary openings arranged in a 24 inch (61 cm) line. The polymers were spun through the each capillary at a polymer throughput rate of 0.40 g/hole/min. Attenuating air was heated to a temperature of 550° F (288°C) and supplied at a rate of 300 standard cubic feet per minute (8.5 m^3/min) through two 2 mm wide air channels. The two air channels ran the length of the 24 inch line of capillary openings, with one channel on each side of the line of capillaries set back 2 mm from the capillary openings. Both polypropylene resins were supplied to the spin block at a rate of 9.0 kg/hr. A bicomponent meltblown web was produced that was 50 weight percent high viscosity polypropylene and 50 weight percent low viscosity polypropylene. The meltblown fibers were collected on a moving forming screen to produce a meltblown web which was collected on a roll. The meltblown web had a basis weight of about 19 g/m^2.

EXAMPLE 2

This example demonstrates formation of a bicomponent meltblown web according to the current invention in which the first component is a blend of high viscosity polypropylene and linear low density polyethylene and the second component is a low viscosity polypropylene.

Multiple component meltblown webs were formed according to the procedure of Comparative Example B except the high viscosity polypropylene component (PP1) was made up of a blend of Equistar GA594 linear low density polyethylene and Exxon 3155 polypropylene. In Example 2-1 the high viscosity polypropylene was blended with the Equistar linear low density polyethylene to provide a blend made up of 25 weight percent high viscosity polypropylene and 75 weight percent linear low density polyethylene; in Example 2-2 the high

viscosity polypropylene was blended with 50 weight percent of linear low density polyethylene; and in Example 2-3 the high viscosity polypropylene was blended with the linear low density polyethylene to provide a blend made up of 75 weight percent high viscosity polypropylene and 25 weight percent linear low density polyethylene. The physical properties of the meltblown webs are reported in Table 3 below.

A visual comparison of the meltblown webs of Example 2, which were identical to the meltblown web of Comparitive Example B except for the absence of the polyethylene blend component in the web of Comparative Example B, showed that the visual uniformities of the Example 2 webs were much better than the uniformity of the web of Comparative Example B. This observation was confirmed with a lower measured Frazier air permeability value for the meltblown webs of Example 2, as shown in Table 3 below. A lower Frazier air permeability is generally associated with better web formation and with finer fiber diameters.

TABLE 3

MELTBLOWN PROCESS CONDITIONS AND MELTBLOWN WEB PROPERTIES

Example	Weight % PE in P1	Weight PP1 (kg/hr)	Weight PP2 (kg/hr)	Weight Ratio (%PP1)	Basis Weight of Meltblown (g/m^2)	Frazier Air Permeability ($m^3/min/m^2$)
B	0	9.0	9.0	50	19	166
2-1*	75	4.5	13.5	25	20	40
2-2*	50	9.0	9.0	50	20	77
2-3*	25	13.5	4.5	75	20	123

Where PP1 is the high viscosity polypropylene component and PP2 is the low viscosity polypropylene component

*In these examples, the PP1 component was made up of a blend of linear low density polyethylene and high viscosity polypropylene.